Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

AECB Staff Annual Report for 1999 on the Canadian Nuclear Power Industry

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On May 31, 2000, the Atomic Energy Control Board (AECB), Canada's nuclear regulatory authority, became the Canadian Nuclear Safety Commission (CNSC). Therefore, any reference to the "Atomic Energy Control Board" or to the "AECB" contained within this document, which presents data for the year 1999, applies henceforth to the Canadian Nuclear Safety Commission (CNSC).

The CNSC regulates the use of nuclear energy and materials to protect health, safety, security and the environment and to respect Canada's international commitments on the peaceful use of nuclear energy.

A major use of nuclear energy in Canada is electricity production. The CNSC maintains a staff at each nuclear generating station to monitor the stations on a day-to-day basis. Specialists in the Ottawa head office work with the on-site staff to accomplish this mission.

Staff assesses every station's performance against legal requirements, including the conditions in the operating licence. To do this staff reviews all aspects of a station's operation and management, and inspects each station.

SUMMARY

This report is the Atomic Energy Control Board (AECB) staff assessment of licensees' performance across the Canadian nuclear power industry in 1999. This is the second year of publication of the industry report in this format. In this year's report, AECB staff have introduced a new set of quantitative performance indicators which have been integrated with inspections and results from events' reviews. As a statistically-significant database is accumulated, these new performance indicators should prove to be a valuable addition to AECB staff assessments of licensees' performance. Using the results of these activities, staff assessed the performance of each licensee, according to one of three categories – acceptable, conditionally acceptable or unacceptable.

In 1999, the industry experienced many changes as new programs were introduced as a result of ongoing improvement initiatives. This year, AECB staff rated industry performance in health and safety, security and the environment as conditionally acceptable. In the area of health and safety, preparation of all stations for the Y2K challenge was an industry strength. Other strong points were in reliability performance of the special safety systems and advancements in the environmental qualification program. In the area of security, AECB staff noted several improvements and, if the progress continues, expect the industry to be fully compliant within a few years. In the area of *safeguards*, AECB staff again assessed industry performance to be acceptable; installation of core discharge monitoring equipment continues to be on schedule. In the area of environment, releases well below *derived emission limits* continued to be an industry strength.

The industry continues to need improvement to eliminate work backlogs. Fire protection program issues, although better at some stations, remained the same or deteriorated at others. A common concern of AECB staff is the licensee staffing and training backlogs associated with new program implementation. This leads to a general conclusion that the pace of improvement was slower than expected at stations where improvement initiatives were scheduled.

Outage management is another area where several stations need to improve. AECB staff assessed outages as poorly planned and executed. Corrective action backlogs also continue to be an industry weakness.

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INTRODUCTION

The Canadian nuclear power industry is concentrated in the eastern part of the country. Figure 1 shows the location of each site, the number and generating capacity of the reactors, and the initial start-up date, licence holders and expiry date of current licences. Of the 22 licensed reactors, eight have produced little or no power since 1998. The four reactors at Bruce A are defuelled and in a layed-up state. The four reactors at Pickering A are in a layed-up state with fuel resident in the reactor core. Bruce B, which comprises four 915 megawatt CANDU reactors, is currently limited to operating at or below 90% power. Darlington, with four 935 megawatt CANDU reactors, is limited to 98% power. The remaining stations are nominally operating at 100% power.

This report is the integration of information gathered through AECB staff assessment activities of the Canadian nuclear power industry's operational safety in 1999. The report makes comparisons where possible, shows trends and averages and highlights significant issues that pertain to the industry at large. Principal sections of the report align with the AECB mission statement – to ensure that the use of nuclear energy in Canada does not pose undue risk to health, safety, security and the environment.

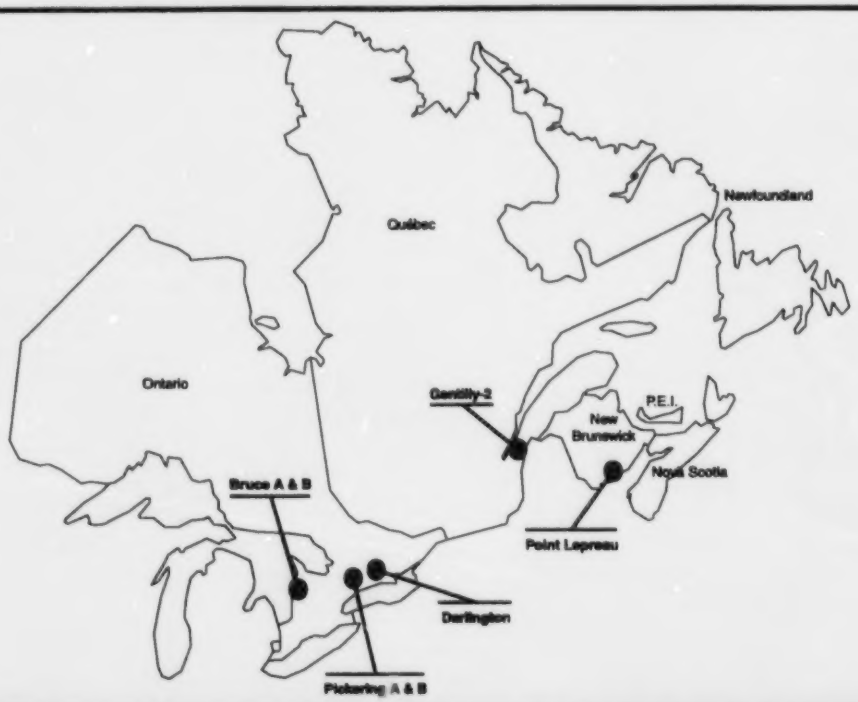
The report's conclusions are supported by facts gathered by AECB staff inspections and document reviews, event reviews and studies of performance indicators. Common findings, event causes and trends across the industry are presented.

The AECB's inspection program is the primary activity by which AECB staff verifies licensees' compliance with regulatory requirements for power reactors. The program includes 31 different inspections, each with a specified frequency that sometimes exceeds one year. Because of the frequency, historically-acceptable licensee performance, or AECB resource constraints, staff may not have inspected all aspects of a station's operation in 1999. However, staff monitored licensees' actions to help ensure that findings from previous inspections were addressed.

AECB staff continually assess every station's performance against codes, standards and legal requirements, including the conditions of operating licences. About 130 AECB staff members are authorized as inspectors of various aspects of the Canadian nuclear power industry. Of these, 25 reside at the sites to monitor facility performance. Other staff with expertise in areas such as radiation protection, *quality assurance*, security and emergency preparedness, also conduct inspections.

Another important method of assessing performance relates to unusual events. By regulation, licensees must report certain events to the AECB concerning station operation. Licensees must further analyze these events to identify causes and determine trends. AECB staff review licensees' reporting and analysis processes to verify compliance with regulatory requirements and licensees' effectiveness in correcting weaknesses.

Figure 1: Locations of Nuclear Power Station Sites in Canada



Station Data

	Bruce A	Bruce B	Darlington	Gentilly-2	Pickering A	Pickering B	Point Lepreau
Licensee	Ontario Power Generation	Ontario Power Generation	Ontario Power Generation	Hydro-Quebec	Ontario Power Generation	Ontario Power Generation	New Brunswick Power
Point Lepreau	4	4	4	1	4	4	1
Gros Electrical Capacity per Reactor in Megawatts	904	915	935	675	542	540	680
Start-up	1976	1984	1989	1982	1971	1982	1982
Licence Expiry	2000-08-31	2001-10-31	2000-11-30	2000-10-31	2001-03-31	2001-03-31	2000-10-31

A third principal assessment activity is the study of appropriate performance indicators. A new set of regulatory performance indicators was developed in 1998. Beginning in 1999, AECB staff collected data on these indicators in the areas of worker safety, public safety, compliance, operations and maintenance. The new performance indicators used in this report have given staff an improved assessment tool for 1999 and beyond. In addition, these indicators will make comparisons and trend analysis more meaningful.

Through these assessment activities and ongoing document reviews, AECB staff identify strengths and weaknesses in licensees' performance and raise issues requiring attention or corrective action. In sub-areas where assessments took place in 1999, staff assessed performance according to the three categories shown in Figure 2. AECB correspondence and assessment reports have already informed licensees of the need for corrective action to improve any sub-area assessed to be less than acceptable.

Figure 2: Performance Assessment Categories

Acceptable	The status of the issue met or exceeded AECB requirements. In some cases, demonstrated progress must be maintained for this conclusion to remain valid.
Conditionally Acceptable	The status of the issue will satisfy AECB requirements if clearly_specified conditions are met. These are issues which required improvement, though which were not of sufficient magnitude to require licensing actions.
Unacceptable	The status of the issue did not meet AECB requirements or, in the judgment of AECB technical specialists, did not meet the expected standard. These are shortcomings which required urgent improvement; licensing actions were proposed or are being taken.

A glossary of technical terms used in this report is provided in the Annex. Terms are italicized on first reference.

Past AECB staff assessments, research reports, Board Member Documents, communiqués, information bulletins, notices and other documents about power reactor licensing are available to the public at the CNSC Library in Ottawa or via the CNSC Web site at *www.nuclearsafety.gc.ca.*

HEALTH AND SAFETY

EQUIPMENT FITNESS FOR SERVICE

AECB staff assessment of a licensee's performance with respect to the fitness of equipment includes design adequacy, maintenance, periodic and in-service inspections, surveillance, reliability and the ability of equipment to function in the harsh environments that may exist as a result of an accident. In addition, AECB staff located at sites routinely inspect station housekeeping and the physical condition of equipment. As in 1998, assessment activities in 1999 showed that all stations' performance continues to be conditionally acceptable. AECB staff have noted improvements in most areas, but training backlogs and changeover problems to new support systems are reasons for the slower-than-expected pace of these improvements. Despite this, AECB staff identified specific industry-wide strengths in:

- the periodic and in-service inspection program;
- special safety system availability in 1999;
- the year 2000 issue; and
- progress in the environmental qualification programs.

In addition, AECB staff credit Ontario Power Generation (OPG), formerly Ontario Hydro, for its work on the newly-released Bruce B risk assessment study, as well as both Gentilly-2 and Pickering B for the voluntary upgrading of the *primary heat transport system* relief valves.

AECB staff identified a number of weaknesses common to a majority of stations throughout the industry. Improvements are required in:

- backlogs in preventative and corrective maintenance;
- life-cycle management programs for major components; and
- fire protection programs.

MAINTENANCE

During 1999, AECB staff continued to monitor OPG's progress in carrying out maintenance improvement projects to reduce backlogs and improve efficiency. AECB staff observed improvement in a number of maintenance functions and in several new maintenance programs that have recently been initiated. For example, in June 1998, OPG convened a special multidisciplinary team at Bruce B to tackle the operating corrective maintenance backlog. This backlog consisted of approximately 1,000 deficiencies per unit. Because of the efforts of the Bruce B team, the operating corrective maintenance backlog was reduced throughout 1999 to 160 deficiencies per unit in December. The reduction was achieved by completion of repairs and cleanup of the database. During the first seven months of 1999, the preventative maintenance backlog was reduced from 240 preventative maintenance jobs per unit to 85 jobs per unit. However, this backlog had steadily risen to 130 jobs per unit by the end of December.

In 1996, then-Ontario Hydro implemented a 13-week, rolling scheduling process at each station to reduce equipment deficiencies and improve maintenance efficiency. The scheduling process involves dividing station equipment into groups. Corrective and preventative maintenance work for a particular group is identified, scheduled and, every 13 weeks, carried out. AECB staff inspection of this scheduling process showed that work completion rates needed to be improved. The rate of maintenance completion was not sufficient to reduce backlogs and sustain the reductions in either corrective or preventative maintenance. The licensee has recently taken steps to improve in this area.

At Gentilly-2, AECB site staff noted an improvement in 1999 in the quality of production of maintenance procedures as well as an improvement in maintenance verification activities. However, Hydro-Québec must still rectify its weak performance of previous years with respect to maintenance backlogs.

At New Brunswick Power (NB Power) both preventative and corrective maintenance backlogs declined in 1998 and 1999.

Table 1 shows the new AECB performance indicator "Preventative Maintenance Completion Ratio", which is equal to the percentage of preventative maintenance jobs completed divided by preventative plus corrective maintenance jobs completed. Higher ratios indicate a proper use of resources in the prevention of running equipment failures. AECB staff expect to see an upward trend of this ratio as industry maintenance programs mature. Since both Pickering A and Bruce A are in a layed-up state, it is expected that they fall below the industry average as maintenance improvement programs concentrate on operating units.

AECB staff assessed this sub-area of maintenance performance as conditionally acceptable for all licensees, the condition being that the maintenance backlogs continue to decline.

Table 1: 1999 Preventative Maintenance Completion Ratio

Bruce A	24%
Pickering A	32%
Bruce B	35%
Pickering B	36%
Darlington	36%
Gentilly-2	40%
Point Lepreau	50%
Industry Average	**36%**

PERIODIC AND IN-SERVICE INSPECTIONS

Licensees carry out periodic and in-service inspections on an ongoing basis to confirm that equipment important to safety remains fit for service. This equipment includes *steam generator tubes, fuel channels, feeders* and other high-pressure components.

The steam generators at Gentilly-2 continued to work well with few significant problems.

NB Power inspected all four steam generators at Point Lepreau in 1999 for boiler tube degradation. Inspections revealed indications of a significant number of possible defects. Several tubes with major indications were plugged and others with lesser indications were dispositioned following engineering review. Two of the four boilers inspected were not part of the original outage plan, but were included because of the inspection findings, thus significantly extending the outage.

OPG's periodic inspections showed that the two main reasons for degradation in steam generators at its stations were fretting and pitting. In 1999, OPG staff proposed fitness-for-service guidelines and life-cycle management programs to address these degradation processes. In late 1999, during cleaning of the steam generator tubes at Pickering B, unit 8, a water hammer incident damaged some small-diameter Primary Heat Transport system piping supports. Non-destructive inspections are continuing to determine if there was damage to the steam generator tubes.

Failure of a small number of steam generator tubes because of fretting and pitting does not pose significant safety concerns. Nevertheless, assurance that steam generator tubes do not deteriorate to the point where a large number could fail can only be obtained through detailed monitoring and management of a steam generator's condition. AECB staff consider that the management program proposed by OPG will provide this assurance. Information generated through the program will provide a good base on which to assess fitness-for-service for steam generators throughout the industry.

Another major component of the licensees' inspection programs monitored by AECB staff is *pressure tubes*. Pressure tube degradation is becoming more difficult to assess because current fitness-for-service requirements do not contain well-defined criteria for rejecting a pressure tube. Licensees continue working to establish a better technical basis for the fitness-for-service criteria and to agree to life-cycle managed processes lasting more than a few years. Pending completion of the technical basis, AECB staff consider the lack of well-defined, fitness-for-service criteria for pressure tubes to be a weakness in licensees' inspection programs. AECB staff concluded that all licensees are presently inspecting a sufficient number of pressure tubes to assure safe operation for the next few years.

During 1999 outages, both Hydro-Québec and NB Power conducted inspections and maintenance on pressure tubes. At Point Lepreau, all required pressure tube inspections were satisfactorily completed to assess the state of previously-identified flaws and identify potential new flaws. Both licensees also completed extensive garter spring location and relocation work to provide assurances that the springs were securely lodged in their design positions. Proper location of garter springs is essential to prevent

pressure tubes contacting the *calandria tubes* and resulting in consequential blister formation on the pressure tubes. Garter springs in 50 channels were repositioned at Point Lepreau and in 64 channels at Gentilly-2.

Licensee inspections, in 1997 and 1998, revealed an unexpected reduction in the wall thickness of some feeders. Research to identify service conditions that contribute to corrosion has been completed and chemistry changes to reduce the corrosion rate have been implemented. Although feeder piping remains fit for service in the short-term, the expected life of some feeders will be limited if the current rate of degradation continues. In 1999, AECB staff requested licensees to define the long-term monitoring and fitness-for-service criteria. As part of the strategy for managing the degradation, licensees identified the relative severity and rate of degradation at their respective stations.

As mentioned in last year's report, following the loss-of-coolant accident at Pickering A in 1994, Bruce B, Darlington, Gentilly-2 and Point Lepreau licensees replaced relief valves similar to those identified as a principal cause of the accident. Those at Pickering B did not need replacement, but OPG decided to replace them with new valves designed not to chatter. AECB staff assessed overall performance of licensees in conducting periodic and in-service inspections to be acceptable at all stations.

PLANT SURVEILLANCE

OPG established a new program to enhance system surveillance practices to ensure early detection of problems and compliance with system-design requirements. This process was implemented at OPG stations in the spring of 1999. AECB staff inspections found that responsible system engineers were following the new process, although full compliance had not yet been achieved. AECB staff inspections showed some difficulties with transferring data to new systems. Until these problems are resolved, AECB staff rate OPG performance in this sub-area as conditionally acceptable.

Although AECB staff at Gentilly-2 did not carry out specific reviews, they found through their routine inspections an improvement in system surveillance activities. AECB staff rated Hydro-Québec's plant surveillance as acceptable.

AECB staff began to review activities undertaken by licensees to improve power-operated valve performance. During 1999, this review was limited to motor-operated valves. For each of the licensees, AECB staff reviews focused on the methods used to ensure that motor-operated valves in the *emergency core cooling system* were capable of performing their design safety function. These inspections identified motor-operated valve deficiency at Gentilly-2 and inadequate documentation at Point Lepreau. Both licensees promptly corrected the deficiencies. The licensees' analyses of the emergency core cooling system valves raised questions of operability both at Pickering B and at Point Lepreau, and AECB staff inspections revealed similar concerns for the emergency core cooling system valves at Gentilly-2. All three stations have planned design changes to these valve actuators to fully resolve problems.

Following a 1998 AECB staff inspection of the electrical distribution system at the Point Lepreau station, the licensee identified corrective actions addressing all the findings and completed one of them during the 1999 outage. Corrective action involved performing maintenance on the emergency power system and to add this equipment to the preventative maintenance program to ensure its continued maintenance on a regular basis.

Hydro-Québec conducted a test during the 1999 maintenance outage of the emergency core cooling valves motor terminal voltage when on battery power. The result of this test provided an acceptable response to the AECB's observation about the Class I power supply for these valves at the Gentilly-2.

RELIABILITY

In 1999, AECB staff assessments showed that licensees' performance across the industry in the sub-area of reliability to be acceptable. All licensees' *special safety systems* met the AECB availability requirement. Although this performance was acceptable, not all predicted availability targets were met. Table 2 shows the new AECB performance indicator "Number of Missed Mandatory Safety System Tests". This indicator measures the ability of licensees to successfully complete all required routine tests on systems related to station safety. There are several thousand of these tests performed annually. AECB staff review each test missed and the licensee is required to provide an event report. Of the tests missed in 1999, none significantly impacted on system availability.

Table 2: Number of Missed Mandatory Safety System Tests in 1999

Station	Special Safety Systems	Standby Safety Systems	Safety Related Process Systems
Bruce B	0	0	0
Darlington	1	0	0
Pickering B	0	0	0
Gentilly-2	2	0	0
Point Lepreau	0	0	0

In 1999, OPG completed the Bruce B probabilistic risk assessment study. This assessment is a tool to estimate and manage risk during station operation and outages. The licensee intends to use the risk assessment's models and results to support operator training, outage planning, safety decisions in plant operation, testing and maintenance activities. AECB staff believe that this risk assessment has the potential to be an important addition to the techniques now used in the decision-making process at the station.

YEAR 2000 ISSUE

The effects of the year 2000 (Y2K) issue could potentially have had an impact on safety and the ability of licensees to meet regulatory requirements. Y2K issues pertained to the potential for date-related problems that could have been experienced by computers. During 1999, AECB staff monitored the progress of licensees' Y2K efforts through a series of meetings and guided walkthroughs of selected Y2K vulnerable-equipment and through the review of submitted documentation. Large-scale Y2K testing was successfully performed at all stations on the control computers. An international exercise, which involved nuclear power stations and the electrical grid throughout North America, took place in September. All licensees participated in this exercise, and used the opportunity for additional testing and rehearsal of their contingency plans. There were no significant problems found during this exercise.

AECB staff were satisfied that AECB criteria had been met in an acceptable manner in Canada and had reasonable assurance that all stations had been adequately reviewed. AECB staff were confident that licensees had taken appropriate measures to ensure that this issue posed negligible risk. All licensees passed through the Y2K transition with no problems related to the operation or safety of their stations.

ENVIRONMENTAL QUALIFICATION

The aim of an environmental qualification program is to provide assurance that equipment needed to mitigate the consequences of an accident will function when exposed to the harsh environmental conditions the accident may create. Additionally, this assurance must exist for the life of the equipment. In 1999, OPG made significant progress on its environmental qualification program. The program is gradually evolving from the engineering to the implementation phase. However, one issue requires further effort. It involves the interfaces between the environmental qualification program and other programs that may have an impact on environmental qualification, such as materials management and procurement engineering. In addition, staffing shortages for the environmental qualification program positions continues to be a problem. As part of their environmental qualification programs, both NB Power and Hydro-Québec have reviewed and revised environmental, qualification-related documentation, including safety analysis, accident room conditions, environmental qualification lists and environmental qualification assessments. During the 1999 outages, both licensees replaced a number of components to correct known environmental qualification anomalies.

As mentioned in the 1998 report, a common issue affecting Bruce A, Gentilly-2, Pickering A and Point Lepreau is the existence of polyvinyl chloride-insulated (PVC) cables in special safety and support systems inside containment. Tests have shown that the PVC insulation might fail in harsh environments. A licensee-sponsored testing program is in progress to resolve this issue.

Although improvements have been made in this sub-area, pending resolutions of the above issues, AECB staff assessed performance to be conditionally acceptable throughout the industry.

FIRE PROTECTION

In 1999, AECB staff carried out general reviews of fire-protection programs at all stations. In addition, as part of a research program, AECB and contractor staff conducted detailed inspections of fire-fighting provisions at Point Lepreau and Gentilly-2. These reviews and inspections indicated the following weaknesses – incomplete implementation of fire-protection programs, limited, fixed-fire suppression provisions, compromised fire separations and poor emergency-response capabilities.

The results of live fire drills witnessed by the AECB contractor at both Point Lepreau and Gentilly-2, were unsatisfactory. Subsequent improvements were confirmed at Point Lepreau and improvements are expected at Gentilly-2.

Emergency response provisions at all OPG stations are being modified in accordance with their integrated improvement initiative. AECB staff and an expert contractor attended a drill of a new emergency response team at the Pickering site and found the crew response, under the limited scenario, acceptable. All licensees continue to review their fire-protection programs and update their fire-hazard assessments. OPG is completing design of fire-protection improvements to turbine generators and to fire detection systems in specific high-hazard areas. However, existing programs are behind schedule.

All licensee facilities continued to require improvements to basic fire-protection provisions. Consequently, AECB staff assessed fire protection as conditionally acceptable across the industry.

OPERATING PERFORMANCE

A review of operating performance includes sub-areas such as station operation, outage management, compliance, major events, corrective actions and feedback from operating experience. In 1999, of the reactors available to provide electrical power, the industry operated approximately 84% of the time; the reactors were in a *guaranteed shutdown state* for the remaining 16% of the time.

At Pickering, AECB staff have expressed concern over a series of events which have the potential to undermine continuing safe operation. A licensee investigation revealed weakness in management supervision and lack of adequate and effective supervision at all levels. These were cited as common causes of these events. In addition, industry weakness in operating performance included the large number of non-compliances, problems in outage management and corrective action programs, as well as the slower-than-expected pace of progress of many of the improvement programs. Consequently, AECB staff assessed operating performance as conditionally acceptable across the industry.

OUTAGE MANAGEMENT

The refusal of Hydro-Québec's staff to work overtime saw Gentilly-2 1999 outage extended by several weeks, however, the outage was completed without incident. Point Lepreau's 1999 outage was extended to 81 days from the planned 46 days. The extension was the result of additional corrective work that was identified during the outage through inspection findings and because of deficiencies in outage planning. Positive observations for NB Power during the outage were the implementation of an effective foreign-material exclusion policy that prevented stray material from being left in opened systems, and improvements in administrative processes that ensure availability of adequate *heat sinks*.

AECB staff at the Bruce and Pickering sites continue to assess outages as poorly managed, despite the efforts of licensee staff to overcome deficiencies. Common problems include outage scope changes, inadequate personnel resources, inadequate lead-time for material acquisition and poor coordination of contractors. AECB staff made some positive observations during OPG station outages. For example, research and testing into teledosimetry was conducted during Pickering B's latest outage. Teledosimetry allows remote monitoring of workers in radioactive areas, both visually via camera and electronically via fixed and eventually personal radioactivity monitors. This new technique should lower radiation doses and address the lack of radiation supervisors available during outages. AECB staff also noted that worker safety continues to be emphasized by the licensee's programs of education on accident awareness and prevention.

At Darlington, AECB staff carried out an inspection of the unit 2 outage in the fall of 1999. While the outage organization and execution were acceptable, several areas such as *contamination* control, foreign material exclusion, and housekeeping could be improved.

COMPLIANCE AND MAJOR EVENTS

Another new performance indicator AECB staff introduced this year is the standard "Non-compliance Index". This index shows the number of occurrences where licensees' failed to comply with its Operating Policies and Principles, Radiation Protection Requirements, Physical Security, Transport or *Atomic Energy Control Regulations*, or with other Operating Licence requirements. Events, which can involve a non-compliance in more than one of the above categories, are reported to the AECB; cumulative results for each station are shown in Table 3. Values for this index will be used to direct AECB staff assessment of licensees' programs.

At OPG, a number of events in 1999 arising from inadequate adherence to procedures demonstrated that there remained considerable room for improvement in compliance. AECB staff at Pickering have highlighted the need for better adherence to the licence and Operating Policies and Procedures. AECB staff at Bruce B have also asked OPG management to address the problem of non-compliances with radiation protection regulations. AECB staff found that the consequences of the majority of non-compliances are minor. However, the number of occurrences are too high and this continues to be an industry weakness.

Table 3: 1999 Non-compliance Index

Station	Number of Reportable Events	Non-compliance Category			
		Operating Policies and Principles	Radiation Protection	Physical Security, Transport or Atomic Energy Control Regulations	Other Operating Licence Non-compliances
Multi-Unit Stations					
Bruce A	43	5	26	12	0
Bruce B	223	53	67	14	27
Pickering A	75	39	6	8	0
Pickering B	116	75	6	3	0
Darlington	141	5	31	1	12
Single-Unit Stations					
Point Lepreau	66	10	1	13	13
Gentilly-2	58	22	10	1	2
Industry					
Industry Total	**722**	**209**	**147**	**52**	**54**

AECB staff introduced another performance indicator which measures the number of unplanned reactor power fluctuations, also known as transients. This indicator shows the number of manual or automatic power reductions from actuation of either the shutdown, the stepback or setback systems. As shown in Table 4, there were two unplanned shutdown system trips at Darlington during 1999. In October, a leaking isolating valve caused a reactor to shut down during testing of the steam generator, low-level parameter. In December, a reactor shutdown system tripped as a result of a simultaneous fault occurring while testing of the neutron rate parameter. There were four reactor power automatic reductions using the regulating system stepback function and five reactor power reductions using the regulating system setback function in response to various system failures. Significant reactor power transients were assessed and reported to AECB staff. AECB staff assessed the completion of the actions related to these events as being acceptable.

An event at Darlington in 1999 involved an explosion in a *moderator* cover gas oxygen addition valve. An operator had started the addition procedure when the incident occurred. As a result, the operator received burns to the face, neck, forearm and hands. OPG placed an immediate ban on the use of oxygen addition at all its nuclear stations. According to an OPG investigation, the most probable cause was that heat generated by the action of opening the valve ignited the valve seat material. Based on information provided, AECB staff approved design modifications to the oxygen addition systems of moderator cover gas, annulus gas and *liquid zone control*. AECB staff have also requested that OPG investigates the need for additional measures to further reduce the risk of combustion in other oxygen addition systems.

Table 4: Number of Unplanned Transients in 1999

Station	Reactor Operating Hours for 1999	Reactor Trip	Reactor Stepback	Reactor Setback
Bruce B	29,700	0	2	2
Darlington	31,600	2	1	2
Pickering B	28,000	0	1	0
Point Lepreau	7,050	0	0	1
Gentilly-2	6,640	0	0	0
Industry Total	**103,000**	**2**	**4**	**5**

In the late 1980s, AECB staff judged that the Darlington shutdown system software needed changes to improve its availability, and instructed the licensee to adopt appropriate software engineering standards and redesign the software. Based on reviews of project documents, monitoring of operational trials and tests, AECB staff concluded that OPG met AECB requirements for installation of shutdown system no. 1 and shutdown system no. 2 redesigned software and approved their installation into operational units. The new software now is installed and running at all four Darlington units.

CORRECTIVE ACTION AND FEEDBACK FROM OPERATING EXPERIENCE

In 1999, backlogs of corrective actions continued to be an industry weakness. AECB staff remain dissatisfied with licensees' performance, particularly in corrective action program awareness and supervision. Inspections of corrective action and operating experience programs were conducted at both Pickering B and Darlington, as well as an inspection of the design change control process at Pickering and an inspection of the configuration management project at Bruce B. These inspections raised several actions on the licensee's corrective action program. AECB staff instructed OPG to take immediate action to correct deficiencies. In recent months, AECB staff have noted that OPG management has taken steps to correct problems. At Hydro-Québec, AECB staff noted an improvement in the corrective action programs, but more is required to bring the licensee up to industry standards. AECB site staff are currently in discussion with Hydro-Québec to ensure that improvements continue. At Point Lepreau, corrective action backlogs increased in 1999. In response, the NB Power implemented a new process to better manage the program. This initiative should provide better follow-up to issues identified by the root-cause identification process. Related to corrective action programs is feedback of information from events that occur throughout the industry. This information is conveyed to all licensees to ensure that any lessons learned can be shared throughout the industry. For example, AECB staff noted Hydro-Québec's quick response to information it received on the oxygen addition event at Darlington; Gentilly-2 staff implemented immediate corrective action to prevent a similar occurrence. AECB staff note that NB Power recently made improvements to its operating experience feedback programs. Feedback from internal operating experience continued to be rated as a strength in AECB staff reports.

However, feedback from external sources is an area needing improvement. At OPG stations, AECB staff is closely tracking improvement initiative programs in feedback from operating experience. Until all stations can show sustained improvement to these programs and a reduction in the backlog of corrective actions, these programs are rated as conditionally acceptable across the industry.

ORGANIZATION, MANAGEMENT AND MANAGED PROCESSES

AECB staff continually assess licensees' work programs such as quality assurance, radiation protection and chemistry control. Also, AECB staff have been conducting research to improve methods of assessing the human element within the managed processes. In 1999, this research helped AECB staff assess the effect of human performance and organizational changes on safety. AECB staff noted significant progress in the sub-area of configuration management at OPG stations and continued progress in the development of human factors programs for licensees assessed in 1999. However, AECB staff found the sub-areas of quality assurance and configuration management to be unacceptable at Point Lepreau. Quality assurance programs at OPG stations remained weak. Overall, the area of organization, management and managed processes was assessed to be conditionally acceptable.

QUALITY ASSURANCE

It is AECB staff's expectation that licensees apply quality assurance standards to the management of their facilities. AECB staff inspections and reviews over the year have all confirmed that more and sustained improvement is required by all licensees. In 1998, AECB staff assessed Point Lepreau quality assurance program as unacceptable. After discussions in 1999, Point Lepreau twice submitted updates to their quality assurance program. AECB staff assessed each revision to be ineffective. Late in the year, Point Lepreau re-submitted replies to outstanding AECB quality assurance actions. However, review of these submissions has shown that Point Lepreau has still not addressed previously identified problems. Therefore, AECB staff continue to assess the quality assurance program at Point Lepreau as unacceptable.

At the OPG stations, many improvements were needed in programs evaluated in 1999. At Pickering, the design change control process was assessed to be deficient. AECB staff found weaknesses in program areas such as design reviews, design plans and procedural adherence. The design activities remained inadequately controlled, as was determined in a similar inspection in 1996. Overall assessment given by AECB staff on the quality assurance programs at Bruce B, Darlington and Pickering B were conditionally acceptable. No inspections of the quality assurance programs were conducted at Bruce A and Pickering A. Over the last few years, AECB site staff at Gentilly-2 have made verification of the quality assurance of pressure-retaining component procedures a priority. Their findings revealed that Hydro-Québec has made steady improvement in both the coverage and quality of these procedures.

RADIATION PROTECTION

In 1999, AECB staff evaluated contamination control of the radiation protection programs at the Bruce and Pickering sites. Although a corrective action plan for contamination control at the Bruce stations had been drafted for their improvement initiative, AECB staff was concerned by the length of time taken. However, acceptable remedial actions have been initiated to correct all but one of the weaknesses identified in the AECB staff inspection. At the Pickering site, an AECB staff inspection of the radioactive contamination control element of radiation protection was conducted in November. AECB staff identified areas of weakness, such as impact assessment for the Zone 3/2 boundary change project, the level of compliance with radiation protection procedures, and the compliance of contamination control areas. AECB staff is concerned with a number of contamination incidents and violations of radiation protection regulations, which could have been avoided by properly observing procedures. AECB follow-up from previous inspections showed that action notices remained open at Darlington and Gentilly-2, but all remedial actions at Point Lepreau had been satisfactorily addressed. At Darlington, these action notices concerned staffing levels and training in the radiation safety department. At Gentilly-2, the action notices concerned adherence to the work planning process.

AECB staff found that the industry continued to perform well in radiation protection. No atomic radiation worker in the Canadian nuclear power industry received a dose in excess of the regulatory limit. However, at Gentilly-2, an event occurred where a contractor who was in the process of obtaining atomic radiation worker status, received a radiation dose in excess of the regulatory limit for a member of the public. AECB site staff were satisfied with the remedial actions taken by Hydro-Québec following the event investigation. Consequently, AECB staff assess the performance in radiation protection of all but one licensee to be acceptable. Pickering site was assessed to be conditionally acceptable pending resolution of actions from the November AECB staff inspection.

CONFIGURATION MANAGEMENT

Overall, in 1999, implementation of configuration management principles progressed at OPG and Hydro-Québec stations, but problems occurred at Point Lepreau. Pickering reduced the number of long-outstanding temporary changes and identified those that were previously inadequately documented. However, AECB staff found instances of licensee staff failing to follow the new processes put in place by OPG. There were also issues of cross-relationships to other programs, such as environmental qualification and maintenance, that have not been resolved. Consequently, AECB staff assessed this program to be acceptable at Bruce B and conditionally acceptable at Darlington and Pickering sites.

Configuration management continued to be a significant weakness at Point Lepreau. Despite NB Power's attempts to improve, deficiencies in configuration management contributed to numerous events. These included a licence non-compliance because of a six-hour unavailability of a standby generator. These issues are compounded by NB Power's longstanding quality assurance deficiencies. In addition the performance improvement program aimed at rectifying the situation is still in the planning stages. Consequently, AECB staff assessed Point Lepreau's performance in this area to be unacceptable.

AECB staff noted that although not all Hydro-Québec program objectives are being met, there has been improvement in configuration management. For example, AECB site staff noted a reduction in temporary changes since 1998. Still a weak area at Gentilly-2 is the turnaround time required for design manual changes. However, AECB staff assessed configuration management at Gentilly-2 to be acceptable.

HUMAN FACTORS PROGRAM

In 1999, licensees requested a number of changes to their organization and management structures. OPG changed the main control room's shift organization at Darlington, Pickering B and Bruce B, as well as their overall radiation protection program management structure. NB Power requested AECB approval of changes in its engineering division organization and management structure. Approvals for these changes were granted after issues identified by AECB staff were satisfactorily resolved.

AECB staff reviewed OPG's approach and detailed procedures for addressing human factors issues during engineering changes. Staff found procedures to be acceptable. Reviews were carried out of human factors plans and analyses produced in support of user interface design changes, such as the critical safety parameter monitoring system at Pickering B, the Darlington shutdown system software redesign and the Pickering A return-to-service project. A number of initiatives, including the formation of a Human Performance Oversight Committee, were initiated at the Pickering site to improve the quality of human performance. Overall, AECB staff assessed performance in this sub-area to be acceptable.

In addition, AECB staff was part of an assessment team that conducted an organization and management inspection at Darlington. The purpose of the inspection was to gather information on the impact of organization and management influences on safety. The inspection was the first of its type using the Organization and Management Review Methodology. Fifteen organizational dimensions identified in the methodology were examined during the inspection. The team conducted interviews and an organizational culture survey. The team also observed work processes such as shift turnovers and a variety of meetings. During this inspection, AECB staff concluded that there was high regard for safety on the part of individuals, and a respect for the hazardous nature of the work. There was also a positive approach and attitude toward communication, a strong work group cohesiveness and a constructive cultural profile conducive to problem identification. The major weakness was the lack of an effective change management process. This gave rise to a number of issues, including a lack of communication of goals associated with the change process to those responsible for their implementation. There were also difficulties in the coordination of everyday work because of additional requirements that the change process imposed on the organization. AECB staff also found differing perceptions of the organization's culture among some of the job categories and a lack of priority-setting and understanding of the programs being implemented.

CHEMISTRY CONTROL

AECB staff introduced two new chemistry performance indicators, the "Chemistry Index" and the "Compliance Chemistry Index" (1999 results are shown in Table 5). The purpose of the chemistry index is to indicate to AECB staff the licensees' long-term control of important chemical parameters at stations. The purpose of the compliance chemistry index is to monitor licensees' performance in meeting AECB requirements for safety-related chemical parameters.

At Pickering B, AECB staff noted the chemistry parameter for dissolved oxygen in the condensate system was problematic during the year. The AECB chemistry index for this parameter showed that it was within specifications only 19% of the time, with the worst unit only within specifications 6% of the time. In addition, AECB staff inspections showed that the water treatment plant condition has been allowed to deteriorate over the years. At Bruce B, AECB staff noted that there were delays in filling management positions in the chemistry organization. The AECB chemistry index showed that all Bruce B units were above the industry average. However, performance under the compliance chemistry index could be improved. At Darlington, the AECB chemistry index showed all units performed well in 1999. In addition, AECB staff noted that Darlington staff were being pro-active, establishing self-assessments on their performance for the chemistry department. At Gentilly-2, an AECB staff review of Hydro-

Table 5: 1999 Chemistry Indices

Station	Unit	Chemistry Index	Compliance Chemistry Index
Darlington	Unit 1	96%	100%
Darlington	Unit 2	94%	100%
Darlington	Unit 3	92%	100%
Darlington	Unit 4	94%	100%
Bruce B	Unit 5	87%	82%
Bruce B	Unit 6	92%	81%
Bruce B	Unit 7	90%	87%
Bruce B	Unit 8	90%	83%
Gentilly-2	Unit 2	90%	95%
Point Lepreau	Unit 1	89%	89%
Pickering B	Unit 5	83%	96%
Pickering B	Unit 6	77%	97%
Pickering B	Unit 7	86%	96%
Pickering B	Unit 8	84%	95%
Industry Total		**89%**	**93%**

Québec's chemistry program showed that licensee staff adhere to the requirements of the program and that the program itself is complete.

Consequently, AECB staff assessed chemistry performance at Darlington, Gentilly-2 and Point Lepreau to be acceptable, while Bruce B and Pickering B were conditionally acceptable.

Table 6: Accident Severity Rate for 1999

Site	Days Lost	Hours Worked	Accident Severity Rate
Point Lepreau	6	1,211,300	1
Bruce A and B	309	5,308,600	12
Pickering A and B	338	5,513,600	12
Darlington	406	5,309,000	15
Gentilly-2	270	1,193,600	45
Industry Total	**1,329**	**18,536,00**	**14**

NON-RADIOLOGICAL OCCUPATIONAL HEALTH AND SAFETY

Table 6 shows the new AECB performance indicator "Accident Severity Rate". This indicator measures the total number of days lost to injury for every 200,000 person hours worked at a site. AECB staff plan to introduce a frequency measure to supplement this indicator. This will give a better understanding of how licensees are performing. Hydro-Québec's high accident-severity rate is the result of one accident early in 1999, where an employee was severely injured.

TRAINING AND PERSONNEL QUALIFICATION

Inspections and examinations conducted by AECB staff indicated that licensees have made some progress toward eliminating weaknesses in training, but some delays in implementing improvement programs and corrective action plans have occurred. Consequently, staff assessed this area as conditionally acceptable across the industry, although the gap to acceptability is considered somewhat less for Point Lepreau.

During 1999, the overall success rate on AECB examinations for shift supervisor and control room operator candidates was 86%. This represents a small decrease from the 1998 overall success rate of 89%. The historical average rate for overall success is 85%. Table 7 provides an overview of the overall candidate success rate on AECB examinations at stations for which examinations were conducted by AECB staff.

Table 7: Candidate Success Rate on AECB Examinations in 1999

Station	Knowledge-based	Performance-based	Overall
Pickering A	100%	100%	100%
Gentilly-2	85%	N/A	85%
Bruce B	75%	100%	83%
Darlington	85%	67%	79%
Pickering B	82%	67%	79%

Before the AECB conducts an examination of any type, the licensee must confirm in writing to the AECB that each candidate has successfully completed the prerequisite training program, which includes a final in-house comprehensive examination. While AECB staff found that in-house simulator-based examinations at some OPG sites are designed and developed adequately to ensure that candidates possess the required knowledge and skills, AECB staff also discovered several deficiencies in the documented method of these examinations. OPG now has developed acceptable corrective action plans.

An important and positive finding of AECB staff inspections in 1999 was the overall adequacy of the policy and standard documents defining the framework for the conduct of training at OPG stations and at Point Lepreau. Successful implementation of these documents should raise training to an acceptable level. Inspection of the training for fuel-handling operators at Point Lepreau showed that these policies and standards were being applied in a systematic way, and that all feedback is being used to regularly update this training program. Training conducted to prepare candidates for new requisite organization positions of shift manager, control room shift supervisor and field shift operating supervisor at OPG was also found to be of good quality. For the leadership and management training at OPG, AECB staff found that satisfactory progress in delivery had been made for some subjects while delays had occurred for others.

Although an inter-licensee committee has worked aggressively to develop a satisfactory method for requalification of authorized staff at all stations, the method proposed had a number of significant differences from AECB expectations. Delays in this work have also occurred, and an acceptable method was not produced in 1999 as expected. AECB staff also noted that unsatisfactory progress had been made by OPG in developing and implementing a continuing training program for authorized staff. The refresher training needs have not been identified as part of the job and task analyses conducted to date, and OPG does not yet have a detailed plan to achieve the improvements on this training defined in its integrated improvement program.

OPG has made some progress in defining the training needed by shift supervisor candidates, in addition to the control room operator training, and submitted part of the supporting documentation to the AECB at the end of the year. No other licensee provided the AECB with information on this issue in 1999. The related AECB regulatory examination for shift supervisor candidates is suspended for all stations until they develop an acceptable training program.

AECB staff reviewed the results of three job and task analyses conducted by OPG. While these analyses constitute an important step in the right direction, in all cases the results were judged not sufficiently complete to establish adequate training. For example, there were important differences in results at various stations that could not be justified by the differences in their design.

The results of inspections by AECB staff at Gentilly-2 showed that although some satisfactory training is being conducted, training is not generally established in accordance with a systematic approach and does not always meet needs. For example, training of operators assigned a supporting role to the control room operator during incidents did not address fully the documented job performance expectations.

AECB staff found that training on the new Work Protection Code at OPG stations was adequate, but that it was not timely and the criteria to determine qualification were subjective. AECB staff also found that although there were some positive outcomes of the limited training self-assessments conducted at OPG, this function was not being fully implemented as per procedures, and the resources dedicated to this function were insufficient. AECB staff found that the new Training Information Management System being implemented at OPG was causing difficulties in planning and record keeping.

All licensees have made progress in eliminating deficiencies noted in previous AECB staff reports. AECB staff found that improvements have been made to the Radiation Protection Authorization training program at OPG to address deficiencies noted by AECB staff last year, but some weaknesses still had to be eliminated before the program could be accepted.

During 1999, AECB staff noted some good points in licensee training and that improvements had been made. However, there are important issues that still need to be corrected. Consequently, all licensees performed to a conditionally acceptable level with respect to training and qualification of staff.

EMERGENCY PREPAREDNESS

In 1999, AECB staff continued to evaluate licensees' emergency response capabilities. Emergency preparedness program inspections were conducted at Pickering and Bruce B, emergency exercises were evaluated at Darlington and Gentilly-2, and emergency plan revisions were reviewed for both Point Lepreau and Bruce A. Staff concluded that licensees were taking appropriate measures to improve their overall state of readiness. Deficiencies identified at Pickering and Bruce B are being addressed to the satisfaction of AECB staff. AECB staff assessed emergency preparedness at Pickering, Bruce B, and Darlington to be acceptable. Bruce A, Gentilly-2, and Point Lepreau were rated as conditionally acceptable.

The Pickering emergency preparedness inspection covered all areas of a comprehensive emergency preparedness program, while the Bruce B inspection was more limited in scope, concentrating on areas needing follow-up from inspections conducted in 1996 and 1997. Nevertheless, staff found that deficiencies at both stations were similar. For example, at both facilities AECB staff discovered that the information in the qualification register used for identifying qualified emergency response personnel on

shift was not reliable. There was also a problem at both stations with the availability of enough calibrated instruments. Some additional weaknesses were identified at Pickering.

Most deficiencies identified in the Pickering and Bruce B inspections have been corrected to the satisfaction of AECB staff, who now consider emergency preparedness at the two stations to be acceptable.

At Darlington, AECB staff evaluated CANATEX-3, a full-scale emergency exercise involving both national and international organizations. The conclusion of AECB staff was that overall, and within the scope of the CANATEX-3 exercise, the Darlington site emergency response organization and the OPG corporate emergency response organization demonstrated their preparedness and competence in dealing with a simulated accident. They also demonstrated competence in the exchange of information on local, national and international levels, and aptitude in decision making. The emergency preparedness program at Darlington was evaluated in 1998 and found to be acceptable. Based on the results of CANATEX-3, this rating continued to hold for 1999.

AECB staff also approved an amendment to the Consolidated Ontario Power Generation Nuclear Emergency Plan which addressed the emergency response organization, minimum shift and site capabilities, and planning basis for emergencies at Bruce A. In 1998, AECB staff commented that Bruce A was moving away from the approved emergency plan. The amendment to the emergency plan more accurately reflects the emergency response strategy for Bruce A while it is in lay-up state.

AECB staff also observed an emergency drill at Bruce A and concluded that there were definite weaknesses in the accounting process at the station. In assessing Bruce A to be conditionally acceptable, AECB staff felt that it warrants additional scrutiny.

At Gentilly-2, AECB staff evaluated an emergency exercise and an emergency drill. Weaknesses were observed in workload distribution for some emergency response personnel. Remedial actions from this and the previous inspections are still outstanding, so AECB staff assessed emergency preparedness at Gentilly-2 to be conditionally acceptable.

NB Power submitted a revised emergency plan to the AECB in 1999. The plan has been reviewed by AECB staff and, although it is apparent that effort had been put into documenting the significant aspects of the emergency preparedness and response program at Point Lepreau, there were elements that needed to be more fully addressed before the plan can be approved.

In preparation for a comprehensive emergency preparedness program inspection, AECB staff visited Point Lepreau in late 1999 to assess NB Power's interface with off-site organizations and its maintenance of off-site emergency facilities. NB Power's interface with off-site organizations was found to be strong. However, work is needed on the adequacy of some off-site facilities. Consequently, AECB staff found emergency preparedness at Point Lepreau to be conditionally acceptable.

SAFETY ANALYSIS

Safety analyses for power reactors are performed to verify that regulatory requirements, such as dose limits, are met to define the safe operating envelope for the reactors and to verify that special safety systems and safety-related systems can appropriately perform their mitigating role during accidents. At many stations, power output was reduced to ensure that operation remained consistent with analyzed conditions. In 1999, AECB staff rated this area of performance as conditionally acceptable throughout the industry. Although progress was made on several fronts, much work remains to be done to eliminate long-standing issues. Major safety analyses used in support of the reactor design or operational changes in 1999 are discussed in the following.

During a large loss-of-coolant accident, the automatic reactor shutdown systems are designed to act quickly to end the power surge caused by voiding of fuel channels. In analyzing this event, licensees include an allowance for the uncertainty in the power surge. In the past, AECB staff have raised concerns over the value of this allowance, and requested licensees to provide additional supporting data. Licensees responded in 1997 by initiating an experimental program, through the *CANDU Owners' Group* (COG). Preliminary results in 1998 showed that the uncertainty allowance could likely be higher. As a result, all licensees have revised large loss-of-coolant accident analyses using higher values. The analyses using the higher values have resulted in higher fuel temperatures to the extent that compliance with certain safety acceptance criteria could not be assured. To compensate, OPG has undertaken operational changes at its Bruce B and Darlington stations.

Flux measurements for the reactor-regulating system, and neutron overpower signals to the two shutdown systems are currently provided by in-core flux detectors. A concern was raised in the early 1990s that some of these detectors may fail because of poor insulation resistance. To address this, a program was developed to replace detectors at the Pickering B station with improved platinum-clad detectors. The replacement program at Pickering was initiated in the fourth quarter of 1995, with detector replacement in unit 6. During 1999, the unit 5 in-core flux detectors were replaced. Similar programs were carried out at Gentilly-2 and Point Lepreau in the early 1990s.

Hydro-Québec requested AECB approval to change the reactor overpower trip set point. The requested change is in the safe direction, and approval was granted. To ensure, however, that the proposed reduction in the trip set point was sufficient to compensate for system aging effects, the AECB staff requested Hydro-Québec to provide details on its plans to monitor the aging of the primary heat transport system, to verify analysis assumptions and report quarterly on the results of its monitoring process. Hydro-Québec has also been requested to confirm that the current physics methods include allowances to account for the effects of aging.

In recent years, the adequacy of the design of strainers for the emergency core cooling system has been assessed. For some accidents, strainer screens could become blocked by debris, thereby inhibiting the flow of emergency cooling water to the reactor core. The situation is a greater concern at Pickering A and B reactors, because their strainers have a much smaller surface area than those at other stations.

OPG has started to modify strainers at Pickering B after choosing a new strainer design, and expects to complete the installation and commissioning of the new strainers in the four units. OPG is also in the process of assessing the adequacy of strainers for Bruce B and Darlington. NB Power and Hydro-Québec are also participating in the relevant COG experimental programs, and finalizing their assessment methodologies for strainer performance.

NUCLEAR SECURITY

Licensees are subject to the Physical Security Regulations, issued under the authority of the Atomic Energy Control Act. They set out the security requirements that licensees must meet. During 1999, following inspections, exercise observations and follow-up inspections, AECB staff assessed all licensees' performance in nuclear security to be conditionally acceptable. While licensees' performance has improved during the past year, AECB staff believe that licensees need to effect more timely corrections to identified deficiencies. Although licensees generally met the regulations, which are minimum requirements, there remains considerable room for improvement to achieve effective security status. Over the past year, all licensees increased support for security programs and AECB staff noted improvements in their station security implementation. Of the 54 weaknesses outstanding by the end of 1998, 50 remained unresolved at the end of 1999. However, this total included new weaknesses identified during inspections in 1999. These weaknesses involve either a non-compliance with procedures and instructions that do or can compromise security, or a direct contravention of regulations, standards or codes.

OPG continued with its upgrade of physical protection measures at its stations. AECB staff have been tracking this project and, while improvement is apparent, progress remains slow. When all proposed security measures are completed, OPG stations will have significantly increased their security capability and should exceed current regulatory requirements. Beyond the more general security upgrade efforts, AECB staff noted that OPG has moved to enhance its security management and organization at all stations.

AECB staff continued to note improvement at Bruce A and B in performance and maintenance of the stations' security systems. OPG continued development of its commitment to significantly upgrade its principal security systems at these two stations. A 1999 inspection at the Pickering site revealed that the majority of its outstanding issues had been satisfactorily dealt with and its security status had improved.

Gentilly-2 and Point Lepreau were inspected by AECB staff in 1999. Both stations showed a marked improvement and were rated as conditionally acceptable. Gentilly-2 had satisfactorily responded to most outstanding security issues and had developed plans for enhancement of its security systems. Point Lepreau's physical protection program still required considerable improvement, as AECB staff have noted for several years in succession. However, the recent inspection verified that action had been taken on several outstanding security issues. If NB Power is successful in following through on its current security enhancement projects, its security profile will have been raised significantly and would bring the Point Lepreau station into full compliance with the regulations.

While not directly specified by the regulations, AECB staff have advised licensees to conduct regular exercises with their respective off-site response forces. These exercises verify preparedness for various contingencies and test the interface between the station and the off-site response force. All licensees have generally accepted this advice and have scheduled exercises accordingly, notwithstanding the need to sometimes pay for off-site involvement and the difficulties encountered in scheduling exercises.

During 1999, Pickering and Gentilly-2 held comprehensive exercises with their respective off-site response force, that is the local police. AECB staff monitored both exercises and found that, while a number of minor weaknesses were apparent in the licensees' contingency plans, the exercises served as an excellent learning vehicle for both management and operational staff. They also provided for appropriate adjustments to the facilities' plans. Bruce B, which last conducted an exercise in 1995, was scheduled to hold an exercise in 1999. However, as a result of scheduling problems with its response force, the exercise was postponed.

SAFEGUARDS

AECB staff assessed the execution of safeguards requirements in 1999 to be acceptable at all stations.

Part of the AECB regulatory mandate relative to the nuclear power industry is to achieve conformity with measures required to implement the international obligations to which Canada has agreed. Canada is a signatory to the Treaty on the Non-Proliferation of Nuclear Weapons. Pursuant to the Treaty, Canada has entered into a safeguards agreement with the *International Atomic Energy Agency* (IAEA). This agreement provides the IAEA with the right and the responsibility to verify that Canada is fulfilling its treaty commitment not to use its peaceful nuclear program to make nuclear weapons or nuclear explosive devices.

Requirements for the application of IAEA safeguards are included in power reactor operating licences and compliance requires licensees to provide timely reports on the movement and location of all nuclear materials, the application of IAEA safeguards measures, including providing access and assistance to IAEA inspectors for verification purposes, as well as for the installation and maintenance of IAEA equipment.

During 1999, all reports required by the IAEA were provided. Additionally, the IAEA successfully accomplished its annual Simultaneous Physical Inventory Verification of fuel inventory, with the cooperation of all licensees. However, an error in accounting was discovered at Point Lepreau, which occurred during the stations' changeover to a new accounting system. Although corrected, this event highlighted shortcomings in quality assurance procedures during software acceptance.

To fulfill its obligation to the world community, the IAEA carries out independent verification activities to draw its own safeguards conclusions. Each year, the IAEA evaluates the results of its activities against inspection goals it sets. Through a formal reporting process, the IAEA Safeguards Implementation Report, the Agency informs member states of its conclusions, including those for Canadian stations and overall goal attainment for Canada as a state. Failure of goal attainment at the station level may thus affect overall goal attainment for Canada. IAEA safeguards inspection goals applied to stations are sub-divided into fresh fuel goals, reactor core goals and spent fuel goals. The 1999 IAEA Safeguards Implementation Report indicated that Darlington, Bruce A, Point Lepreau and Gentilly-2 met all IAEA inspection goals.

In 1999, IAEA inspection goals for fresh and spent fuel were met by all licensees. Reactor core goals were not attained at Pickering A, Pickering B and Bruce B because of the inability to satisfy safeguards criteria for the reactor cores and fuel transfer routes.

To complete the safeguards approach at the above stations, installation of IAEA core discharge monitors is proceeding as IAEA resources and reactor access allow. Funding required for the purchase and installation of the monitors is a high-priority for the IAEA, and the AECB is investigating ways in which their installation could be accelerated. The installation of monitors designed to meet IAEA inspection goals for reactor cores and fuel transfer routes was completed at Bruce A in 1998, resulting in this station meeting its core goals in 1999. Monitor installation was also completed at Bruce B, unit 5, in 1999 and, when installed at unit 6, this station will be in a position to meet its core goals. The installation contracting process is underway at Pickering A and B and the station has provided the required estimates and schedule for the installation of monitors. Installation of core discharge monitors at the CANDU multi-unit stations is a high priority for both the IAEA and Canada as completion will effectively remove these facilities from the IAEA Safeguards Implementation Report listing of problem areas in safeguards implementation.

In some cases, the meeting of IAEA goals was jeopardized by actions at the sites which required investigation and resolution. There were breakdowns in procedure at Bruce A and B, permitting an unannounced movement of flasks capable of removing safeguarded material from the site. At Bruce A, the event involved the movement of a booster rod flask in the spent fuel bay. The station realized the safeguards impact of the movement and notified the AECB. An internal investigation concluded that the level of understanding regarding safeguard compliance was insufficient within the organization. OPG will be issuing instructions to all sites, providing clarification for flask movement and revised station procedures to address the situation. At Bruce B, the licensee failed to provide advance notification of the removal of shield plugs routed to an ancillary port. Bruce B staff has amended procedures related to this operation to ensure advance notification in the future. In a similar situation at Point Lepreau, exposure of IAEA radiation monitoring instrumentation occurred when shield plugs were routed to an ancillary port. The licensee has undertaken to reinforce the training of fuel-handling operators with respect to safeguards at the station. The IAEA was provided detailed information on the above actions, including an indication that resolution of these issues is in progress and will not affect the 1999 goal attainment.

All scheduled nuclear material transfers were successfully verified in 1999. The safeguards effort required for the verification of transfers of nuclear material accounted for a large portion of IAEA person days of inspection in Canada. This effort included verification of spent fuel interbay transfers at Bruce B and transfers to dry storage at Pickering and Point Lepreau. In addition, effort was required for the monitoring of flask movements capable of removing safeguarded material such as cobalt shipments at Gentilly-2 and Bruce B. The AECB and the IAEA, in cooperation with the licensees, have developed and implemented a scheme to successfully confirm that cobalt flask movements do not contain spent fuel at Bruce B and Gentilly-2. This will reduce the level of effort and intrusion required while giving the licensee staff flexibility on scheduling shipments.

In 1999, through its Protocol Outreach Program, the AECB continued to keep the Canadian nuclear industry informed of the advent of a new phase in safeguards characterized as the Strengthened Safeguards System. This system will be implemented with the coming into force of the Additional Protocol to Safeguards Agreements. Canada signed the Additional Protocol in September 1998 and will implement it following the promulgation of the Nuclear Safety and Control Act and its regulations. To ensure consistency and clarity of safeguard requirements and to aid in Protocol preparation and implementation, the AECB normalized safeguard licence conditions in 1999.

ENVIRONMENTAL PERFORMANCE

A review of environmental performance includes sub-areas such as radioactive and conventional waste management, effluent and environmental monitoring, unplanned releases, assessment of environmental protection managed system programs, compliance with the public dose limits and compliance with provincial environmental regulations. AECB staff assess licensees' monitoring activities using data on emissions from the stations, inspecting environmental radiation protection programs and reviewing associated documents. AECB staff did not conduct any on-site environmental assessments in 1999.

From the review of data on airborne emissions and liquid releases for all stations, releases to the environment were consistently well below the derived emission limits. In addition, doses to the most exposed members of the public were well below the regulatory limits. As in previous years, this continues to be a strong trend throughout the industry. However, emission data alone are insufficient to assess licensee performance. AECB staff reviewed documentation pertaining to corrective actions taken by OPG at the Pickering and Bruce sites. At Pickering, AECB staff reviewed documentation relating to the 1998 AECB inspection of the radiological environmental monitoring program. Of the four notices identifying the need for corrective action, two were closed and two remain open. The open notices relate to the production of supporting documents and the acceptance of the program's quality assurance measures. AECB staff also reviewed OPG's corporate quality assurance manual for the environmental monitoring program. Staff concluded that several procedure manuals need to be prepared and submitted for review before the program can be considered acceptable. Preparation of these procedure manuals has been incorporated into the environmental action plan evolving from the 1998 Pickering environmental effects inspection.

In 1996, AECB staff conducted an inspection of the radiological environmental monitoring program at the Bruce site. During 1999, OPG upgraded the Bruce environmental monitoring program and continued to address AECB staff comments. AECB staff found that OPG had made significant progress in the improvement of the environmental monitoring program at Bruce. However, until the corporate environmental program documentation is updated, AECB staff assessed the environmental monitoring program to be conditionally acceptable for both the Pickering and Bruce sites.

In 1997, AECB staff reviewed Point Lepreau's operational environmental radiation monitoring program. NB Power indicated that it would respond to AECB staff comments by March 31, 1999. However, AECB staff did not receive the revised Point Lepreau monitoring program documents at the expected time. Therefore, AECB staff assessed NB Power's environmental monitoring program to be conditionally acceptable.

In 1999, AECB staff assessed OPG compliance with the Ontario regulation on effluent monitoring and effluent limits, also known as the *MISA* (Municipal Industrial Strategy for Abatement) Regulation. All OPG stations experienced difficulty in achieving compliance with both monitoring and quality requirements in spite of significant liquid effluent treatment and monitoring modifications being

completed on major effluent streams at the end of 1999. There are also numerous other MISA control points, some of which had non-compliance issues in 1999. While further assessment and modifications by OPG are planned and a system is in place to address non-compliant liquid effluent, Ontario Ministry of Environment staff considered MISA compliance issue resolution to be ongoing.

CONCLUSIONS

Licensees operated their stations safely in 1999.

Based on its assessment activities for the year, AECB staff continued to assess the overall performance in health and safety, security and the environment as conditionally acceptable across the industry.

Figure 3 shows how AECB staff assessed each station in the principal areas of the AECB inspection program. Licensees' performance improved from previous years in the sub-areas of reliability, emergency preparedness and radiation protection. All stations maintained their acceptable performance of previous years in the sub-areas of periodic and in-service inspections and safeguards. In the sub-area of human factors, all stations assessed during 1999 were deemed to have performed acceptably. In the remaining areas assessed as conditionally acceptable, staff have identified weaknesses that licensees must correct. In the sub-areas of quality assurance and configuration management, Point Lepreau's performance was assessed as unacceptable. AECB staff is currently in discussions with NB Power to rectify this situation.

Staff identified industry-wide strengths in the following areas:

- the periodic and in-service inspection program;
- special safety systems availability in 1999;
- the year 2000 issue;
- progress in environmental qualification programs;
- radiation dose control through new technological developments;
- human factors programs; and
- radiation protection.

A number of weaknesses common at a majority of stations throughout the industry were:

- backlogs in preventative and corrective maintenance;
- life-cycle management programs for major components;
- fire protection programs;
- large number of non-compliances;
- outage management;
- corrective action programs; and
- quality assurance.

In most cases, the programs put in place to correct deficiencies in past performance have not reached a mature stage in their implementation. AECB staff have identified concerns of resources and training which could affect the sustained improvement shown to date.

Figure 3: AECB Staff Assessments of Nuclear Power Station Performance in 1999

AREA	Bruce A	Bruce B	Darlington	Gentilly-2	Pickering A	Pickering B	Point Lepreau
HEALTH AND SAFETY							
EQUIPMENT FITNESS FOR SERVICE (Overall)	○	○	○	○	○	○	○
Maintenance	○	○	○	○	○	○	○
Periodic and In-Service Inspections	●	●	●	●	●	●	●
Station Surveillance	○	○	○	●	○	○	—
Reliability	—	●	●	●	—	●	●
Environmental Qualifications	○	○	○	○	○	○	○
Fire Protection	○	○	○	○	○	○	○
OPERATING PERFORMANCE (Overall)		○	○	○		○	○
Station Operation	—	○	○	○	—	○	○
Corrective Action Program	—	○	○	○	—	○	○
OPEX Program	—	○	○	●	—	○	○
ORGANIZATION, MANAGEMENT& MANAGED PROCESSES (Overall)		○	○	○	○	○	○
Quality Assurance	—	○	○	○	—	○	●
Procedural Adherence	—	○	○	○	○	○	○
Configuration Management	—	●	○	○	○	○	●
Radiation Protection	—	●	●	●	○	○	●
Chemistry Control	—	○	●	●	○	○	○
Human Factors	—	●	●	—	●	●	●
TRAINING AND PERSONNEL QUALIFICATION (Overall)	○	○	○	○	○	○	○
Examination and Qualification of Authorized Personnel	○	○	○	○	○	○	○
Training Program	○	○	○	○	○	○	○
EMERGENCY PREPAREDNESS (Overall)	○	●	●	○	●	●	○
SAFETY ANALYSIS (Overall)	○	○	○	○	○	○	○
NUCLEAR SECURITY							
NUCLEAR SECURITY (Overall)	○	○	○	○	○	○	○
SAFEGUARDS (Overall)	●	●	●	●	●	●	●
ENVIRONMENTAL PERFORMANCE							
ENVIRONMENTAL PERFORMANCE (Overall)	○	○	—	—	○	○	○
Effluent and Environmental Monitoring	○	○	—	—	○	○	○
Compliance with Provincial Environmental Regulations	●	●	—	—	●	●	—

LEGEND: ● - Acceptable ○ = Conditionally Acceptable ● = Unacceptable — = Not Assessed in 1999

GLOSSARY

Atomic Energy Control Regulations
Regulations made pursuant to the Atomic Energy Act providing further detail on the legal requirements for the use of nuclear energy.

calandria tubes
Calandria tubes surround the *pressure tubes*. The space between the tubes is filled with inert gas that thermally insulates the moderator from the coolant.

***CANDU Owners' Group* (COG)**
An organization formed by agreement in 1984 among the three Canadian CANDU-owner utilities (Ontario Power Generation, Hydro-Québec and New Brunswick Power Corporation) and Atomic Energy of Canada Limited. It provides a framework for cooperation, mutual assistance and exchange of information for the successful operation and maintenance of CANDU stations.

contamination
The presence of radioactive material anywhere it is not wanted, particularly in places where its presence may be harmful.

***derived emission limit* (DEL)**
A calculated amount of radioactivity that, if released from the station, would result in a radiation dose of five milliSieverts (5 mSv) to a member of the public in the worst possible case. Five mSv is the maximum annual radiation dose allowed for members of the public by the *Atomic Energy Control Regulations*. It is calculated by examining the effect of the radioactivity on a theoretical person who resides full time at the station boundary, eats only food harvested locally and drinks only water from the station's discharges. This theoretical individual is known as the "critical individual".

emergency core cooling system
An automatic system that injects cold water into the reactor's fuel channels if there is a problem with the normal coolant system. It also provides long-term cooling for the fuel by recovering water from the reactor building floor.

feeder
There are several hundred fuel channels in the reactor. The feeders are pipes that supply heavy water coolant to each channel and return the hot coolant to the steam generators.

fuel channel
A fuel channel consists of a *pressure tube* which contains fuel, end fittings connecting it to the *feeders* supplying heavy water coolant, and closure plugs that can be removed by the fuelling machines for refuelling. Each pressure tube is located inside a *calandria tube*, which separates it from the cold *moderator* heavy water. Carbon dioxide gas between the pressure tube and the calandria tube provides insulation for the hot pressure tube.

guaranteed shutdown state
A method for ensuring that the reactor is shut down. It includes adding a substance to the *moderator* which absorbs neutrons and hence removes them from the fission chain reaction, or draining the moderator from the reactor.

heat sink
This is any system used to dissipate heat produced in the fuel. At all times, a main heat sink must be in service, normally the steam generators, and an alternative or backup heat sink must be available. Failure to dissipate the heat produced in the fuel by means of an adequate heat sink can increase the temperature of the fuel and thereby damage it.

***International Atomic Energy Agency* (IAEA)**
A United Nations agency, it provides a system of safeguards to make sure that states do not divert nuclear materials to non-peaceful activities. It also provides an international forum for nuclear safety.

liquid zone control
The primary means for regulating reactor power level and the spatial distribution of power in the core. Ordinary water is introduced in varying amounts into each of 14 zone control units. The variation of neutron absorption by this ordinary water provides local control.

***MISA* (Municipal Industrial Strategy for Abatement)**
Ontario Regulation 525/95 "Effluent Monitoring and Effluent Limits - Electric Power generation Sector" is also known as the MISA Regulation. This is the result of the initiative of the province of Ontario know as the Municipal Industrial Strategy for Abatement.

moderator
The heavy water system that surrounds the *primary heat transport system* of a nuclear reactor. The moderator slows down fast neutrons thus increasing the likelihood of nuclear fission in the reactor core.

negative pressure containment
The building surrounding the reactor. It is designed to contain the effects of any accident involving the reactor, isolating any hazard from the public.

pressure tubes
Tubes that pass through the calandria and contain 12 or 13 fuel bundles. Pressurized heavy water flows through the tubes, cooling the fuel. They form part of the pressure boundary for the *primary heat transport system*.

primary heat transport system
A closed cooling circuit that carries heat produced in the fuel bundles to the steam generators. It circulates heavy water at high pressure through fuel channels and steam generator tubes.

quality assurance
A formal program of standards, procedures and checks controlling the quality of work at the station.

safeguards
An international program of monitoring and inspection carried out by staff of the International Atomic Energy Agency. Safeguards ensure that nuclear materials in the station are not diverted for non-peaceful uses.

special safety systems
There are four independent special safety systems – shutdown system one or shutdown system two shuts down the reactor if a problem occurs, the emergency core cooling system provides cooling and the containment system contains any radioactivity.

steam generator
A heat exchanger that transfers heat from the heavy water coolant to ordinary water. The ordinary water boils, producing steam to drive the turbine. The steam generator tubes separate the reactor coolant from the rest of the power-generating system.